Madagascar had better invest in a single land transportation infrastructure

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ABSTRACT

Madagascar invests large amounts of money in road infrastructure in parallel with investments in railway infrastructure and rail subsidies. However, there is no economic justification in Madagascar for investing in two land transport infrastructures in parallel. The amounts of money that can be spent are as expected limited resulting in inadequate amounts of money for both the rail infrastructure and the road infrastructure bringing about poor infrastructures and inferior transportations. Madagascar had better invest in a single land transportation infrastructure as the well-known proverb "A bird in the hand is worth two in the bush" advises.

Keywords: Madagascar, Railway System, Road Network

INTRODUCTION

Isolated, small countries do not have beneficial motives for the construction of dual land transportation infrastructure - roads and railways. A mainland country, even a very small country can have a railway system aiming at connecting the small country to its adjacent countries like Monaco which is a tiny country of only 2.2 km^2; however Monaco railway system's aim is connecting Monaco mainly to France, but also to other countries in Europe. In fact, the railways passing through Monaco are operated by the French National Railways (SNCF) [1].
Railways on islands adjacent to a populated mainland also exist like Long Island near New York, United States [2], Sicily near Italy in Europe [3], and Hainan near China in Asia [4]. The distances of these adjacent islands from the mainland are listed in Table 1. Madagascar is much further than these islands and therefore cannot be deemed a portion of the mainland.
Adjacent islands usually make use of bridges [5], tunnels [6], or ferries [7] in order to connect the railways to the mainland, so adjacent islands can be actually deemed undivided portions of their adjacent mainland. Madagascar however is a long way away from Africa, so no bridge, tunnel or ferry is available and there is no intention to construct one, nor is there an achievable plan for that.

Island name	Distance from mainland (km)	Connected by a rail or a road to a mainland
Long Island	0.3	Yes
Sicily	3	Yes
Hainan	20	Yes
Madagascar	420	No

Table 1. Distance from selected islands to mainland

BACKGROUND

Isolated territories as remote islands like Madagascar do not have an economic viability for a dual land infrastructure, although Madagascar is much larger than Monaco. Dual land infrastructure will possibly turn out well only in a large densely populated territory where many people need to travel to the same location at the same time [8]. In Madagascar such a massive demand does not occur, so only one land infrastructure should be chosen.
Madagascar is one of the poorest countries. The land infrastructure is absolutely not comparable with any first world country. Many roads can turn into completely impassable roads following heavy rainfalls which often occur as can be seen in Figure 1.

Figure 1. A road after heavy rainfalls

The rail service is also quite poor. Locomotives often fail and tracks are sometimes blocked. Train rides as well as road travels are often completed in incalculable delays. Actually, train delays of even several hours are unexceptional in Madagascar.
Rail systems aim at transporting a large amount of people, whereas roads aim at transporting from one person to a full bus. In Madagascar there is rarely a need for transporting a large

amount of people, so the loss making railway system should go out of business and all the transportation budget had better channeled to the inadequate road system.
Even in developed countries there are many locations where the connections between the different means of transportation are not appropriately arranged. Usually there are several conflict needs and as a result there is no way to fulfill them all [9]. In Madagascar the connections between the railway system and the buses is completely inadequate. Some of the railway stations do not even have a road close to them. This state of affairs of the railway system often dissuades people from using the railway system. Investing in one kind of infrastructure can eliminate the need for connections and will give a better service for the residents of Madagascar.
There are several islands in the world that do not have a railway system. All of these islands have a better economy than Madagascar. Their GDP is higher and their residents have a better transportation service. Madagascar should follow them and relinquish the rail systems in the island of Madagascar. In the next section some of these islands will be surveyed.

COMPARING MADAGASCAR TO ISLANDS WITHOUT FUNCTIONING RAILWAYS

Cyprus is an island with a similar road network size to Madagascar's road network size; however, while Madagascar has a railway system that loses about USD 2 million each year, Cyprus invests only in the road network. During the British rule in Cyprus in 1905, a railway in length of 122km and 39 stations was constructed. It was active for 46 years until 1951 when it was closed. During these years the railway system has continuously operated at a loss and this was the reason for the cessation of the train service in Cyprus. Currently there are some remnants of the railway system throughout Cyprus, but no active rail system exists in the entire island of Cyprus [10].
Another island with a similar rail saga is the island of Trinidad. A railway system was constructed under the British rule in Trinidad. The railway was longer than the railway in Cyprus – 173 kms and it was active for a longer period of 96 years. It was inaugurated in 1876 and was operational until 1968. The spreading out of private automobile technology has brought about changes in the travel preferences of Trinidad and the losses of the railway system have increased. Unlike Madagascar, The government of Trinidad figured out that investing in an unprofitable railway system was unreasonable and decided to close the unsuccessful rail system in 1968 and has been concentrating on road paving. Nowadays, there is no railway system in Trinidad [11].
On another island, the plans for a passenger railway system have never been materialized. The Ottoman government pledged to construct a passenger rail system in Crete in 1908; however, nothing of these plans actually took place and the First World War put the seal on all the ottoman efforts to construct a railway system in Crete. After the First World War in 1922, a railway was constructed in Crete for a particular purpose - the construction of the harbor in Heraklion. It was an industrial railway with no passenger rail service. When the government of Crete finished constructing the harbor in 1937, there was no reasonable use for the train. Therefore this rail system was abandoned and nowadays there is no railway system in Crete. There are some rail fans in Crete trying to encourage the government of Crete to construct a new railway in Crete, however, there is no economic logic in such a railway system and therefore the mainstream politicians in Crete do not support constructing a new railway system in this island [12].
The Negros Island in the Philippines is famous for his Sugar mills. Actually, sugar production is the most common business on the Negros Island. Therefore, railways were constructed from 1912 and on in order to transfer sugar canes from the fields to the mills. Even when the railroads construction was finished, nobody tried to use them for passengers, because nobody believed

such a rail passenger system had a chance to be profitable. The trains have continued to transport sugar and to be profitable until the crash of the sugar price in the international markets. This crash began in the mid of the 1980s, but has continued for too long. Actually, the rail system was gradually closed until 2007 when the last railway located on the east coast of the island was closed [13].

The sugar industry in Madagascar is also very common. Actually, sugar is the second main crop of Madagascar after rice. In 2018 four million tons of rice were produced, whereas 3.1 million tons of sugarcane were produced. Five sugar factories have operated in Madagascar during the years. Four of these sugar factories have employed railways at some point in time. Most of these railways have been abandoned due to similar reasons of the abandonment of the railways in the Negros Island. One of these abandoned railways in a Madagascar sugar factory is shown in Figure 2. For that reason the sugar industry can no longer be a motivation for allocating budget resources for the rail system of Madagascar [14].

Figure 2. An abandoned railway in a Madagascar sugar factory

The government of The Philippines plans to construct a new bridge that will connect several islands in The Philippine. The project is called Iloilo–Guimaras–Negros–Cebu Link Bridge which is actually not one bridge, but rather a network of bridges in the Philippines that will connect the islands of Panay, Guimaras, Negros, and Cebu; however, this planned network of bridges will be only for roads and no railway will be constructed on this network of bridges [15].

The saga of the railways in Jamaica is quite similar to the saga of the railways in the Philippines. The railways in Jamaica are very old dated to 1845 [16]. Actually, the rail system of Jamaica is one of the oldest in the world and it is the first railway system outside of Europe and North America [17]. The British government that ruled Jamaica at this time, granted permission to the Smith's Brothers to construct the railways and to operate the rail system. Essentially, Jamaica was the second British colony that had a railway system and was followed by many other British colonies that a railways system was constructed in. After 34 years of private operation (from

1845 to 1879), the private ownership ended when the Government of Jamaica nationalized the railway system in the island. This was the beginning of increasing losses of the railway system; however, the main reason for the collapse of the railway system was the automobiles that began arriving at Jamaica some years later. The rail system could not successfully compete with the automobiles. So, it was looked like the railway system is going to be closed, but in the 1940s, bauxite deposits were discovered which revived the ability of the railway system to be essential; however, this revival has not lasted forever and it gave just partial justification for the passenger rail system, because it justified maintenance of only part of the passenger railway systems, so in 1992 the passenger rail system was closed. In point of fact, it was the beginning of an unpleasant period for the rail system when it was intermittent for several decades until the government of Jamaica decided to finally close the entire unsuccessful system in 2012 so as to stop losses caused by an unproductive transportation system. The money saved from subsidies and maintenance of the ineffective rail systems shifted to road paving and road infrastructure construction which indeed helped release many traffic congestions and improve traffic flow. Madagascar can also improve traffic flow by shifting budget from the rail system to road paving and road infrastructure construction.

The policy of constructing railways in colonies was not an exclusive policy of the British government toward its colonies. The government of Germany also initiated railways construction in its colonies with the aim of boosting the local economy and as a result collecting more taxes. As part of this policy Germany decided to construct a railway system in New Guinea. The construction has cost dozens of millions of German marks and the railway system could not justify this amount of money and the operation was also loss-making, even though during the German rule in New Guinea, the automobiles have not yet arrived there. These losses have opened some deliberation whether to close the unsuccessful system, but no decision had been taken before the First World War when Australia conquered the island. The Australian Military Administrator of the Territory of New Guinea Colonel Samuel Augustus Pethbridge saw the documents of the ineffective railway system and after a short discussion, he decided to close it and since the end of the First World War there is no active railway system in New Guinea [18].

These cases of islands without an active railway system can let us figure out that a railway system in an island could be a reasonable transportation solution before the arrival of the automobiles. Nowadays when automobiles are prevalent all over the world and there is no country without automobiles, a railway system in an island cannot compete with the automobiles and therefore investing in railway systems in islands is an unjustified capital spending and Madagascar is no exception.

COMPARING MADAGASCAR TO ISLANDS WITH UNSUCCESSFUL RAIL SYSTEMS

There are also several islands with a railway system; however, these railway systems cannot compete with the roads and the investment in double land transportation infrastructure in islands has not been productive.

A well-known ill-reputed rail system on an island is Tren Urbano in Puerto Rico. Puerto Rico is an island in the Caribbean Sea. The residents of Puerto Rico have been United States citizens since 1917; therefore they can freely move between Puerto Rico and the United States mainland; however, Puerto Rico is an unincorporated territory, so the residents of Puerto Rico cannot vote

for the president and the vice president of the United States. Puerto Rico is quite far from the closest location in the mainland of the United States. In point of fact, Puerto Rico is located approximately 1,000 miles southeast of Miami, Florida; therefore, no bridge or tunnel construction is feasible.

The railways of Tren Urbano are just 10.7 miles and consist of 16 stations. Even though the government of Puerto Rico privatized many transportation infrastructures like two of its toll roads PR-5 and PR-22 in 2011 and the largest airport in the island - Luis Munoz Marin International Airport in 2013, no one wanted to buy Tren Urbano as it is a total failure and causes significant losses [19]. Therefore, Tren Urbano is owned by the Government of Puerto Rico. Puerto Rico's Highways and Transportation Authority is in charge of running this unsuccessful train. This authority often complains about the financial difficulties of Tren Urbano. Actually, the bottom line is that Tren Urbano runs at a massive loss [20].

When the rail system was planned, the planners anticipated a minimum ridership of 115,000 passengers every day. However, even though the rail system was inaugurated on December 19, 2004, 14 years later in 2018 the average weekday daily ridership was still just 18,600. In a hearing before the Subcommittee on Regulatory Reform, Commercial and Antitrust Law in 2015, the representative of Puerto Rico's Highways and Transportation Authority was very unenthusiastic: "There are rising operating subsidy requirements to the Tren Urbano light rail, an underperforming and underutilized asset, which has long been a burden on the overall system. Recent reports also indicate that the system has stopped paying third-party vendors amid mounting cash flow pressures" [21].

In 2014, there was a major debt crisis in Puerto Rico. Several bonds issued by the government of Puerto Rico were demoted to "junk" status because the government of Puerto Rico was not capable of paying its debt. This demotion in fact prevented the government of Puerto Rico from selling new bonds in the open market; therefore the government of Puerto Rico increased taxes while cutting public services and government pensions; however, the government of Puerto Rico did not stop the services of Tren Urbano [22], even though many of the unpaid bonds were sold in order to finance Tren Urbano and added $2.25 billion to the total debt [23]. Unfortunately, on average the railroad cars of Tren Urbano were 90.43% empty before the COVID-19 outbreak and now they are even emptier. Therefore Tren Urbano has been increasing the debt of Puerto Rico with very little contribution to the residents of Puerto Rico.

In 2019 the GDP per capita of Puerto Rico was US $32,873.72, whereas the GDP per capita of Madagascar was US $523.36. Madagascar had a ratio of Government Debt to GDP of 44.80 percent in 2020. The national debt of Madagascar grow from US $4.03 billion in 2016 to more than US $7.1 billion in 2021 and the bonds of the government of Madagascar are now labeled as "B-" which means they are very nearly to be labeled as "junk" [24]. In view of the fact that Madagascar has less money and a lower GDP, continuing to invest in the railway system as Puerto Rico does can drive Madagascar to a debt crisis as Puerto Rico has been suffering from.

The GDP per capita of Ireland in 2019 was even higher than the GDP of Puerto Rico – US $78,660.96, so even though Ireland is an island, Ireland can afford a larger railway system of 1,200 miles [25]. The subsidy for Iarnród Éireann – the Irish railway company is undeniably overpriced. The government of Ireland pays every year US $887 million as a subsidy to Iarnród Éireann; however, after this openhanded support, the railway system in Ireland has just 2.7% rail-electrification rate in 2016 which is the smallest rate in the European Union and overall the railway functions ineffectively and poorly developed [26]. As a result, the annual rate of travel is

just 1.7 billion passenger-kilometers which presents a considerable subsidy cost of US $0.52 for each passenger-kilometer [27].
The subsidy cost in China for each passenger-kilometer is just US $0.087, much lower than the subsidy cost in Ireland, even though China has an enormous railway system with many railways that their necessity is open to doubt. The total annual rate of travel in China is 1,470.664 billion passenger-kilometers and the amount of subsidy in China is US $128 billion, so in point of fact Ireland with the free market economy pays 6 times more subsidy for its railways system than China with the planned economy and after that gets a substandard railway system [28].
Unfortunately, the economy of Madagascar does not completely implement a free market; however there are several good moves towards a free market that the government of Madagascar takes [29]. More involvement in the transportation market will not be one of them, so instead of a substantial amount of subsidy to the unsuccessful railway system, an investment in the road network infrastructure can be more reasonable and acceptable.
Another country with a substantial budget and a minor throughput of the railway system is Israel. Even though Israel is part of the Middle East, Israel is in fact an island. Israel is surrounded by the Mediterranean Sea and Arab countries – Lebanon, Syria, Jordan and Egypt. Lebanon and Syria are enemy countries of Israel and from time to time there are even armed conflicts between countries [30].
Jordan and Egypt are not formally considered as enemy countries of Israel, but the commute is sparse. Only in the Hajj which is an annual Islamic pilgrimage to Mecca in Saudi Arabia, there is some increase in the commute volume because there are Israeli Muslim residents travel from Israel to Saudi Arabia via Jordan and the border crossings between Israel and Jordan are getting busier. At present, there is no train from Israel to any adjacent country.
On a regular basis, Israel Railways runs at a considerable loss and the only way to keep Israel Railways alive is subsidizing the company by an immense ratio of 85% [31]. The annual loss of Israel Railways is paid by The Israel ministry of transportation and it is essentially 25% of the entire budget of The Israel ministry of transportation [32].
Occasionally there are a small number of overloaded trains; however most of Israel Railways routes are usually unfilled. In fact Israel Railways railroad cars on average are just 30% occupied [33]. Even with these generous subsidies along with the unfilled and roomy railroad cars, just 5% of the travels in Israel are carried out by Israel Railways [31].
In the twenty-tens, the ministry of transportation of Israel decided to upgrade both the railway and the road to the capital of Israel – Jerusalem. Road no. 1 which is the main road to Jerusalem was expanded from 2 lanes to 3 lanes and a new route of railway was constructed. The upgrade of road no. 1 has cost NIS 2.35 billion [34]. The railway upgrade has cost much more. About NIS 10 billion have been spent on this project [35]. The number of people traveling on each of the infrastructure does not reflect the amount of money spent on each infrastructure. On road no. 1 averagely 133,000 vehicles travel every day. This amount of vehicles includes buses and other types of vehicles that transfer several passengers. In view of that, more than 200,000 passengers averagely travel per day on Road no. 1 [36]. On the contrary, in the railway 3.1 million passengers traveled in a period of 457 days from October 2018 to December 2019 which is 6,783 passengers that averagely travel per day [35]. The road is the key and most important transportation infrastructure, whereas the rail transfers only a very small portion of the passengers. Nonetheless, the rail gets a much larger portion of the transportation budget. This budget allocation does not make sense.

Madagascar invests much smaller resources in its transportation infrastructures. The result of this underfinance is unsatisfactory transportation infrastructures that harm the economy [37]; however, the budget widening should be done intelligently. Spending the new additional budget on a rail which is surplus to requirements will not boost the unfortunate economy of Madagascar.

UNSUCCESSFULNESS OF RAIL SYSTEMS IN ISLAND

The data along with the discussion in the previous sections point out that constructing a railway on an island is more than likely going to be a failure. Successful rail system can only do well in a large territory with a large number of people. Railways aim at transferring a large number of people and finding a large number of people that wish to go from one place to another at the same time is very rarely feasible in an island.

We can find remunerative railway systems in the northeast region of the United States of America which is USA's densest region and includes these states: Massachusetts, Connecticut, New Hampshire, Maine, Rhode Island, Vermont, New York, Pennsylvania, New Jersey, Virginia, Maryland, West Virginia, Delaware, and the District of Columbia. In this region more than 74 million people live [38]. In addition, the northeast region is linked to the rest of the United States and also to Canada. Yet, not all the routes in this region are profitable. Amtrak's Hartford Line from New Haven to Springfield for example runs at a loss. Additionally, it is needless to say that all Amtrak routes outside the northeast region run at a loss [39]. Essentially, only routes that have a completely opposite state of affairs have a possibility to be profitable.

Most of the island of Madagascar consists of regions of sparse population [40]. The densest region in Madagascar is Antananarivo which is the capital city of Madagascar. However, enough people that wish to go from one location to another location at the same time and will give a good reason for a railway cannot be found even in Antananarivo and certainly cannot be found in any other region in Madagascar.

SOLUTIONS AND RECOMMENDATIONS

"A bird in the hand is worth two in the bush"

There are towns in Madagascar that are accessible by only one kind of transportation infrastructure – a railway or a road and in most of them the infrastructure is in poor condition. So, there is really no choice between the two means of transportation. Also, in some cases there is a need for a connection between the two means of transportation in order to go from one place to another. The parallel investment in both roads and railways has shown inadequate results.

The rail infrastructure in Madagascar

Not enough money has been allocated for rail infrastructure in Madagascar since the railway inauguration almost hundred years ago [41]. The maintenance has been performed on the odd occasion and the current overall condition of the railways, the locomotives and the railroad cars is unsatisfactory.

There was a World Bank investment plan from 2003 and 2010 in which the Madagascar rail system received a sum of $49 million; however, unfortunately the institutional crisis in 2009 had

a negative effect on the decision whether to continue this plan and actually it put an end to the plan. In addition, those $49 million were like a drop in the ocean for such a poor infrastructure system. So, the effect of this financial plan on the Madagascar rail system was quite minor [42].
Actually, the railway network is very small – just 670 km from Toamasina to Antananarivo and Antsirabe. In addition, there is an additional railway between Moramanga and Lac Alcoa dedicated for carrying chrome from a mining site. Unconnected to this 670 km of railways, there is also another small railway of 163 km between Fianaransoa and Manakara in the south of Madagascar.
The current railway infrastructure has too many flaws. To begin with, the diversity of standards for the railways is unreasonable. Actually, three are different kinds of railways. Additionally, many wooden sleepers have been damaged during the last years and need urgent maintenance. Furthermore, several bridges are in unsafe condition and urgently must be repaired. There are also slopes that must be revamped so they will not be a danger for the users of the trains. The railway stations are old with leaking roofs as can be seen for example in Figure 3 in the railway station in Andrambovato. All-in-all, the current condition of the rail systems in Madagascar is intolerable and even caused fatal accidents with a tragic loss of life [43].

Figure 3. Andrambovato railway station

The improper condition of the rail system is the cause of a very poor speed which hardly can exceed 20 km/h in most of the railway sections. In the better railway segments the maximum speed can be higher 40-45 km/h. These speeds are very low compared to rail systems in developed countries.
The government of Madagascar has signed a contract with a commercial company named Madarail that granted Madarail a 25-year concession to operate two rail lines in the north of Madagascar. However, the poor condition of the rail system is an extensive hindrance to the ability of Madarail to accomplish its mission. When taking all of the current parameters into account, it is not surprising that Madarail has been quite far from achieving a net profit since the beginning of the concession without the subsidies of the government of Madagascar.

The road infrastructure in Madagascar

The road network size of Madagascar is relatively small. If we compare it to another island – Cyprus, we can draw an unfortunate conclusion for the residents of Madagascar. The size of Madagascar is 587,041 km² and its population is 27 million, whereas the size of Cyprus is 9,251 km² and its population is 0.88 million. Nonetheless, the road network size of both of the islands is almost the same – about 21,000 km. Obviously, the residents of Cyprus have a much better transportation service than the residents of Madagascar even though there is no rail in Cyprus. The kms of road per person in Cyprus is much higher, because the population of Cyprus is much smaller.

The road density in Madagascar is also small compared to the other countries in Sub-Saharan Africa and in addition just about 10 percent of the roads are in a reasonable condition. Furthermore, due to the lack of budget, in many rural roads no maintenance is done and as a result the overall road network size has been shrinking by about 2000km per year [44].

The low quality of the roads imposes a low speed on the vehicles. In fact, most of the vehicles do not travel on the better road sections at speeds higher than 60 km/h; however, these better road sections are just about 10 percent of the road network. In the other road sections the average speed is commonly below 15km/h. Maintenance remains limited due to limited finances but needs to be increased to ensure road quality does not further deteriorate.

Road number	From	To
RN1a	Maintirano	Tsiroanomandidy
RN1b	Analavory	Tsiroanomandidy
RN8	Morondava	Bekopaka
RN10	Andranovory	Ambovombe Afovoany
RN11	Mananjary	Nosy Varika
RN12a	Tôlañaro	Vangaindrano
RN14	Ifanadiana	Vohitrindry
RN15	Ankazoabo	Beroroha
RN16	Ranotsara	Iakora
RN17	Manankoliva	Bekily
RN18	Vangaindrano	Midongy du sud National Park
RN19	Soalala	Katsepy
RN23a	Moramanga	Anosibe An'ala
RN24	Mananjary	Vohilava
RN32	Antsohihy	Mandritsara
RN33	Ambatondrazaka	Ambondromamy
RN55	Morombe	RN 9

Table 2. Completely unpaved roads in Madagascar

Many roads throughout Madagascar are in such bad condition that they should be repaved rather than the usual maintenance. Other roads are completely unpaved and they are dirt roads [45]. Table 2 lists these roads. One of these unpaved roads - RN8 is shown in Figure 4.

Figure 4. Road RN8

Besides the roads in Table 2, many roads are partially unpaved. As the population increases, the transportation needs increase, but due to the lack of budget, essential development is not done.
In the view of limited resources, toll roads can also be implemented in Madagascar as a supplement to the roads the government of Madagascar paves. Toll roads are typically constructed in a scheme of Build–Operate–Transfer (BOT) model, whereas a private commercial company gets a concession from the government to finance, construct, operate, and collect money from the drivers in the toll road. In this way the private company can regain its investments in the road as well as regaining the operating and the maintenance expenses [46,47].

LOOKING TO THE FUTURE

The current transportation equipment in Madagascar is completely outdated as can be seen for example in Figure 5. Nonetheless, in order to predict the future means of transportation in Madagascar, we should look at the means of transportation that are now adapted in developed countries.

Figure 5. Current transportation state of affair in Madagascar

Nowadays there are vehicles that can completely travel by themselves although these vehicles are not yet allowed to travel on public roads in most of the world including all the underdeveloped countries and Madagascar is not an exception to the underdeveloped countries. Such vehicles are called "autonomous vehicles" or "driverless cars" [48]. Autonomous vehicles are now permitted in four states in the US – Arizona, California, Michigan and Ohio. There are other locations where the autonomous vehicles are pending [49]; however, it will take a long time until autonomous vehicles are available in Madagascar, but they will arrive in Madagascar one day in the future. When they arrive, they will make the rail even more unattractive [50].

Even when it comes to public buses which convoy fewer passengers than a train, their ability to compete with the autonomous vehicles is implausible [51]. Buses go on the same infrastructure as the autonomous vehicle whereas rails go on another infrastructure, so the maintenance and the construction costs of railway systems are higher. Buses can also have a stop near more destinations and their routes can be more flexible than the routes of railways. Consequently, if buses cannot compete with the autonomous vehicles, then a fortiori, neither can railway systems [52].

People often argue that traffic jams can be eased if more people will prefer to travel by rail systems and leave the roads; however, the main reasons for traffic jams are explained in [53]. Drivers of non-autonomous vehicles often drive differently. They make different decisions to the same situation in the way they turn the vehicle, apply the brakes and accelerate. According to [53], these differences are the preponderant explanation for traffic jams. Many inexplicable traffic jams are created when one vehicle travels on a dense road and the driver of this vehicle decides to slow down, even slightly, because of an object on the side of the road, a bird in the sky or any other reason that objectively does not require slowing down. The driver in the vehicle behind it will most likely slow down even more, and typically this slowing down can propagate backward through a long vehicle line. This slowing down will typically get severer the farther the slowing down propagates. In the long run, vehicles that do not stop will even hit the vehicles ahead, so these vehicles will have to fully stop in order to avoid an involvement in a car accident [54]. There are intelligent transportation systems that can monitor these jams [55,56,57] and can direct the vehicles to alternate routes; however, autonomous vehicles take a different approach. They ease the traffic jams by letting many more vehicles go in one lane during a specific time. According to [58], the capacity increase can be up to 473%.

Unlike traditional vehicles, autonomous vehicles drive themselves very similarly. All the companies strive to turn the vehicle, apply the brakes and accelerate in the most optimal way [59], so the driving is in point of fact almost the same. This way of driving can eliminate most of the traffic jams. The autonomous vehicles will even go on the road in a long line with a small distance from the vehicle ahead and at the same speed [60]. Such a long line of autonomous vehicles is called platoon [61] and it looks like a train with many railroad cars; however, unlike a train, the components of the line can be easily split and after the split each of them can go to another direction. In this state of affairs, the technology of platoons of autonomous vehicles will have prominent advantages over the railway system because a platoon of autonomous vehicle is much more flexible and can take any passenger to anywhere a road is presented, whereas a railway system are essentially unalterable and can take the passengers only from one predefined station to another predefined station [62].

CONCLUSIONS

Railway systems in isolated territories are redundant. They cost too much for their very modest contribution. Refraining from investing in the railway system can save a large amount of money. Investing the saved money in roads will have a much better impact on the economy of Madagascar and the transportation service for the residents of Madagascar.

The capital invested by the government of Madagascar in the railway system should be gradually reduced. In this interim period roads that can take the place of the railways should be paved and progressively the rail systems can fade away.

All-in-all, Madagascar does not have enough financial resources to develop and maintain two kinds of infrastructure. Therefore, Madagascar should abandon the railway network and dedicate itself to developing a reasonable road network.

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